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MEASURING THE LONG-TERM EFFECTS OF ACTION WORKOUTS

THESIS

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THESIS

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Abstract

This study analyzed aircraft inspection data to determine if quality enhancements were realized after an Action Workout (AWO) was accomplished. Pretest and post-test assessment data from three separate units were analyzed to determine whether overall quality improvements were made.

This study operationally defined quality in terms of Quality Verification Assessment ratings compiled before and after each AWO event. Comparisons were made to determine if overall quality improved, declined, or remained unchanged. Parametric t-tests and nonparametric chi-square analyses were used to determine the significance of any differences between the pretest and post-test data sets.

The results provide plausible evidence that quality enhancements can be realized as a result of Action Workouts. Results at two of the three units analyzed indicate that overall quality of major aircraft inspection processes improved considerably, possibly as a result of the Action Workout intervention. Results at the third site, however, remained essentially unchanged.

The evidence also suggests that many of the changes and improvement ideas implemented during the AWO are seemingly intact and being utilized by respective maintenance personnel. This may also indicate process owner "buy-in" and acceptance of change, two essential principles of quality improvement. This research establishes a firm foundation for future research efforts.

MEASURING THE LONG-TERM EFFECTS OF ACTION WORKOUTS

I. Introduction

General Issue

Throughout the past decade, reduced defense spending has led to major force reductions in the military. While the emphasis on spending continues to escalate, so too does the demand for military service. Force drawdowns and continued demand for military services have resulted in the military having to do "more with less." Operations tempo has not diminished with the force reductions and base closings. Peacekeeping missions throughout the world (e.g. Bosnia, Iraq, and Somalia) have demanded, and will continue to demand, military presence for an uncertain number of years to come. General Richard E. Hawley, Commander, Air Combat Command (ACC), summed up the current operating environment of one of the leading USAF Commands in a speech delivered at the 1996 quality symposium:

> One of our goals in ACC is to cut our cost of operations by 30 percent...But the only way we can achieve a 30 percent reduction in the cost of operating is by following a clearly defined, easy-to-follow road map. That's what our quality tools give us. We are making *action workouts* and six sigma landmarks on our journey to continuous improvement in Air Combat Command. These tools are bringing quality to life for our people. That's what "quality Air Force" means: bringing quality to life for our people. They're helping us work smarter, rather than harder. We're getting our work done faster and safer by doing things the right way once, instead of over and over again. A lot of the tough issues we face -- high operations tempo, and shrinking budgets among them -- can be addressed by the tools called action workout and six sigma. (Hawley, 1996)

In order to meet the challenges of maintaining readiness and sustaining increased operations tempo with fewer resources, military commanders are forced to operate more efficiently. Quality management philosophies were adopted to assist commanders in meeting these challenges. In the United States Air Force, an aggressive quality improvement tool known as an Action Workout (AWO) is being used in conjunction with quality management concepts to cut costs and improve key processes. Hope among the Air Force leadership is, this will ultimately allow for a leaner, more efficient Air Force (Action, 1997). Air Combat Command's Action Workout Team was awarded Vice President Gore's *Hammer Award* for excellence in government in July 1996 (Action, 1997). The *Hammer Award* is presented to federal employee teams "who have made significant contributions in support of reinventing government principles" (Action, 1997). Dramatic success stories abound and the Action Workout craze has quickly become a staple in the Air Force's quality culture (DoD, 1996a: 1-3). The Air Force believes that, in addition to increasing productivity and reducing process cycle times, they will also achieve lower total costs and higher levels of quality. Many stories report the success of AWO's in terms of process savings, but are these savings coming at the expense of overall quality? The purpose of this study is to investigate this critical question and determine whether reduced cycle times are realized at the expense of the overall quality of the process.

Action Workout Defined

According to The Quality Approach, the Air Force's handbook on quality, an Action Workout is defined as "a rapid, concentrated, high-energy, team effort to make

dramatic productivity improvements in any organization" (DoD, 1996b: 41-45). Action Workouts focus on eliminating non-value added work and are designed to reduce cost, work hours, and cycle times of key processes. The seven primary sources of waste and inefficiency that constitute non-value added work are rework, inventory, waiting, over production, excess motion, redundant processing, and transportation and conveyance (DoD, 1996b; 41-45). Action Workouts consist of a five-step process: (1) Identify A Candidate Process, (2) Conduct Site Visit, (3) Unit Preparation and Data Review, (4) Action Workout Event, and (5) Follow-on Actions (DoA, 1996: 4).

Step 1: Identify A Candidate Process. A candidate process for an AWO must provide an opportunity to radically improve cost, defects, waste, or overall cycle time. Opportunities should be verified based on a review of pertinent data such as process performance measures, unit strategic plans, and operational readiness inspection reports. "The primary consideration should be high potential for significant gains in efficiency." After a process is identified, the unit commander formally invites the headquarters Action Workout Team to begin Step 2.

Step 2: Conduct Site Visit. The site visit allows the AWO team to provide training to the unit on AWO concepts and gives the team exposure to the identified process. Also, the critical path, or, "long pole in the tent" for the process is identified. The critical path determines what key subtasks should be targeted for improvement.

Step 3: Unit Preparation and Data Review. The unit's primary objective during this step, which is commonly referred to as the pre-work, is to collect data on the process in its current, unaltered state, to establish a baseline on which all improvements will be measured during the AWO event. Baseline data consists of, but is not limited to, cycle

times, man-hours, and distance traveled for each subtask. Units use videotapes of the process and key subtasks to ease the collection effort, which may require approximately two to three weeks to accomplish.

Step 4: Action Workout Event. The actual AWO event lasts just five duty days; no more and no less. Process owners systematically and vehemently attack waste by eliminating non-value-added steps and creating innovative changes. A unique aspect of the event is "trystorming," which means physically testing every improvement idea in the process and documenting the results of the improvements as the event goes on. Trystorming, as opposed to brainstorming, ensures that all ideas are given ample opportunity for incorporation into the improvement effort. The major premise is to "accomplish," not "discuss." To facilitate radical change, the AWO team brings headquarters functional policy experts, engineers, and technical order specialists to the event to clear obstacles and make on-the-spot changes to policy and written procedures. Activities during this phase embody the term "Action Workout."

Step 5: Follow-on Actions. The process improvement follow-through phase ensures actions that could not be completed during the five-day event are properly addressed. A list of actions is turned over to the unit commander for his/her action over the proceeding thirty days. Progress reports and results are forwarded to the Commander, Air Combat Command, for final review.

The Air Combat Command Quality and Management Innovation Squadron describes AWO as a primary tool for attacking waste in critical work processes. The AWO philosophy is secured in the belief that decreasing process cycle time can attain significant increases in productivity, efficiency, and quality. It is also believed that as

process cycle times are reduced, other dimensions of work processes, such as cost and quality, are forced to improve as well (Action, 1997).

AWO Success Stories

In 1997, Air Mobility Command reported that Action Workouts saved $24 million (Hickey, 1997b). An AWO conducted at Fairchild AFB, Washington, for example, produced a dramatic 50% reduction in man-hours required to process reparable aircraft parts (Hickey, 1997a). Mobility processing improvements at McGuire AFB, New Jersey led to a 60% reduction in unit processing times. This translated into a man-hour savings of over 90% (Hickey, 1997a). The AWO conducted on the B-1 Bomber phase inspection process at Dyess AFB resulted in the elimination of approximately 100 man-hours, 64,000 feet of travel distance, and 65 hours of cycle time (Hawley, 1996). Other examples include cutting the F-15 phase inspection cycle time at Mt Home AFB from 7.1 days to 5.4 days, a 24% improvement (Action, 1997).

In total, Air Mobility Command and Air Combat Command combined to perform more than 40 Action Workout events since 1996, and they are gearing up to perform many more in the years to come (Hickey, 1997a; Action, 1997). Proponents of AWO provide compelling evidence for tangible process improvements. Less compelling is the evidence for overall improvements in quality.

AWO's in Practice: Phase and Isochronal Aircraft Inspections

An Action Workout can be implemented in virtually any process. In Air Combat Command, for example, a process is a candidate for an AWO if a *need* exists to improve

cycle time (Action, 1997). This study will focus on Phase and Isochronal (ISO) aircraft inspection processes. These major scheduled inspection concepts differ only in terms of scheduling criteria and are critical to ensuring the safety and airworthiness of major weapon systems in the Air Force. Phase inspections are scheduled on the basis of aircraft flying time, while ISO inspections are scheduled according to average daily utilization rates (DoD, 1996a: 2-4). The scheduled inspections are performed in accordance with technical order requirements and consist of thorough visual and non-destructive inspections of critical areas, systems, and structures. Operational checks, time compliance technical orders, and other special inspections are also performed. Major inspection processes are integral to preventive maintenance requirements for the majority of the fleet.

Inspection process. Maintenance personnel assigned to the Inspection Section at each of the identified units accomplish major (Phase/Isochronal) aircraft inspections. The actual composition of each inspection section may vary according to unit organizational structures, but typically is made up of aircraft, specialist, and weapons systems maintenance personnel. Inspections are accomplished in four phases: (1) Pre-inspection phase, (2) Look Phase, (3) Fix Phase, and (4) Post-inspection Phase.

The "pre-inspection phase" consists of pre-inspection meetings, aircraft preparation, and inspection area preparation. Aircraft washes are also accomplished prior to the actual inspection, which is performed during the "look phase" of the process. The inspection is accomplished according to applicable technical order procedures and all discrepancies noted during the look phase are documented. The next phase is referred to as the "fix phase." The fix phase consists of correcting discrepancies found during the

look phase and accomplishing preplanned or other scheduled maintenance. The "post-inspection" phase consists of performing operational checks, and if required, preparing the aircraft for flight (DoA, 1997: 120-122). Depending on the weapon system, major inspections require approximately five to ten duty days to accomplish. The inspection section dock chief must notify quality assurance upon completion of the inspection, so that an assessment of the inspection can be made.

Quality Verification Assessments. According to ACCI 21-101, Quality Assurance is required to perform a Quality Verification Assessment (follow-up) of every major aircraft inspection to verify that the inspection was properly accomplished (DoA, 1997: 128). All discrepancies noted during the Quality Verification Assessment (not the actual inspection) are documented and entered into the Quality Assurance database. Discrepancies are classified (by Quality Assurance) as either major or minor defects. Defects that may lead to severe damage to equipment or injury to personnel are classified as major defects. An example of a major defect is a foreign object, such as a screw, bolt, or a piece of safety-wire, found in an engine inlet. A minor defect is a missed or incomplete inspection item that will not result in excessive damage to equipment or safety of flight. Some examples of minor defects are torn seat cushions, dirty windows, or loose fasteners.

Problem Statement

The Action Workout motto, "Radical Improvement...Right Now" accurately describes the potential effectiveness of this quality improvement tool. Action Workout's have been proven successful in dramatically reducing waste and cycle times in many

critical work processes. These reductions are then reflected in terms of man-hour and cost savings. With the emphasis being placed on results, this "radical improvement" in reduced cycle time may only be realized at the expense of secondary processes or measures, possibly degrading the overall quality of the process.

Question

The research question in this study is: Does an Action Workout improve the overall quality of aircraft major inspection processes?

Objective

The objective of this study is to gather and analyze aircraft inspection data to determine if quality enhancements are realized after an action workout is accomplished.

To obtain a representative sample of inspection results, Quality Verification Assessment data were collected from three separate Quality Assurance inspection teams who conduct maintenance assessments/inspections on the A-10, EC/RC-135, and E-3 weapon systems at the 355 WG, Davis Monthan AFB, AZ, the 55 WG, Offutt AFB, NE, and the 552 ACW, Tinker AFB, OK, respectively. The three teams were chosen primarily because of the availability of data and represent a wide array of inspection requirements and improvement opportunities.

This research will operationally define quality in terms of Quality Verification Assessment ratings gathered *before* and *after* each Action Workout event. Three potential outcomes are possible from a comparison of before and after data: (1) Quality

Verification Assessment ratings improve after the intervention, (2) Quality Verification Assessment ratings stay the same, or (3) Quality Verification Assessment ratings decline.

II. Literature Review

Introduction

Action Workouts are one of several process improvement tools the Air Force has adopted to implement "Quality Air Force," the Air Force's approach to Total Quality Management (TQM). Quality Air Force is defined in The Quality Approach as "a leadership commitment and operating style that inspires trust, teamwork, and continuous improvement everywhere in the Air Force" (DoD, 1996b: 1). Other process improvement tools include, but are not limited to, benchmarking, process reengineering, and the continuous improvement process (DoD, 1996b: 31-54). Action Workouts exhibit characteristics of Scientific Management, Total Quality Management, and Continuous Improvement. The literature surrounding these concepts is explored.

Scientific Management

In the early 1900's, the beginning of the industrial revolution, continuous improvement efforts began to take shape under the umbrella of Scientific Management. Fredrick Taylor, otherwise known as the Father of Scientific Management, initiated the efforts that would revolutionize American manufacturing. Taylor believed in using scientific methods to find the "one best way" to produce. He also believed that managers had a responsibility to provide workers with necessary resources and training to do their job (Evans and Lindsay, 1996:108-109). Workers were told what to do and how to do it by top management, who held all decision-making authority. With a focus on efficiency and productivity, Scientific Management principles made the United States the world's leading industrial power (Evans and Lindsay, 1996: 109). According to Taylor,

Scientific Management is based on four principles: (1) Scientific analysis and documentation of work methods, (2) Scientific selection of workmen, (3) Bringing together the science and the man, and (4) Division of work (Taylor, 1987: 72-75; Thurston, 1998: 3).

In the first principle, "Scientific analysis and documentation of work methods," Taylor advocated using scientific methods such as time and motion studies, to systematically collect the "great mass of traditional knowledge" from workers, and formulate specialized, standardized, and simplified ways to perform elements of work (Taylor, 1987: 72; Thurston, 1998: 3).

Action Workouts exemplify this principle in almost every regard. Examples exist in the first four steps of the AWO process. The very first step of the AWO process requires process owners to systematically analyze data to determine a candidate process for an Action Workout. Once the process is identified, more analysis is required to seek out the critical path and key subtasks. Process owners, management, and the headquarters AWO team work in concert to determine the critical path. During step three of the AWO process, "Unit Preparation and Data Review," data is collected from historical archives, observation, and analysis of videotapes to establish baselines for the AWO process measures (Action, 1997). During the event, AWO team members implement time and motion study tools to formulate process improvements. The "spaghetti chart" is an example of a common tool used by AWO team members to document time and motion of a particular process (Action, 1997). The spaghetti chart in Figure 1 illustrates employee movements and work paths for a particular subtask on the B-1B phase inspection, *after* AWO improvements were made. To facilitate the

standardization of processes, improvement ideas and innovations are communicated throughout the Air Force so that similar benefits can be made by all.

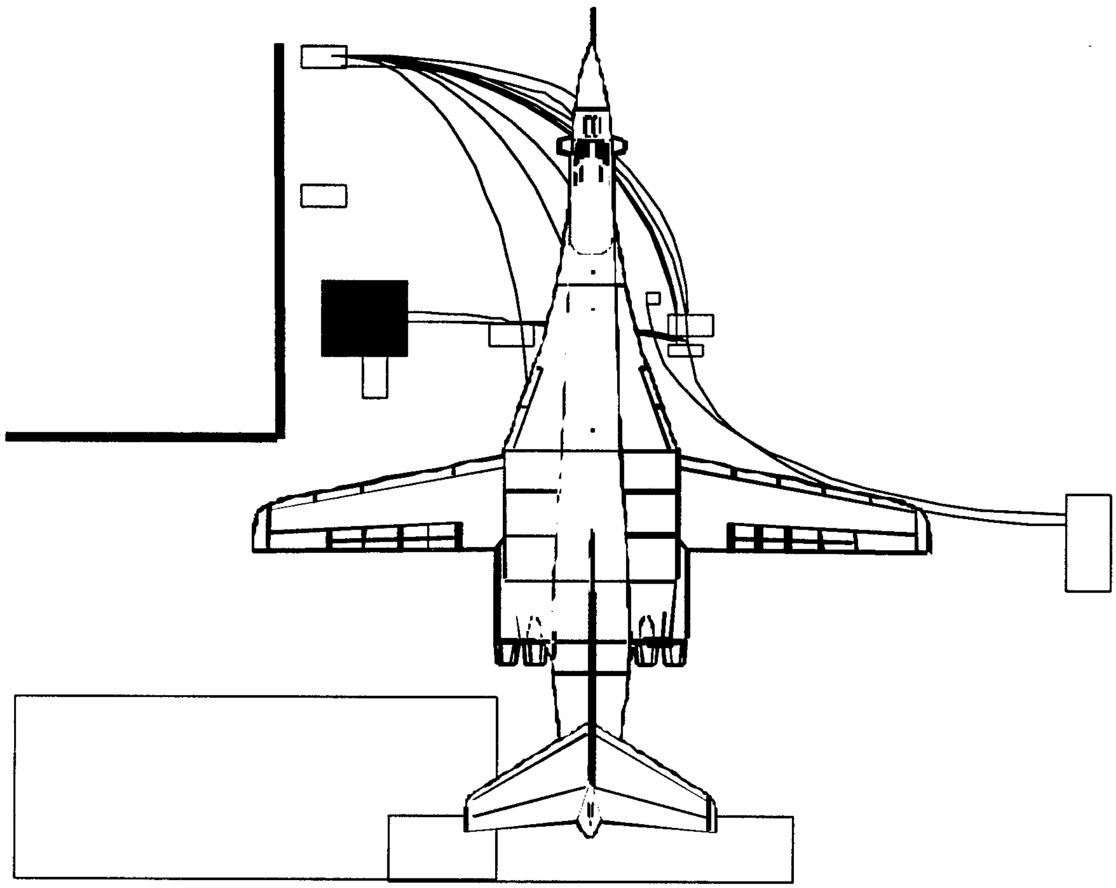

Figure 1. Spaghetti Chart, B-1B Phase AWO (Action, 1997)

The second principle, "Scientific selection of workmen," suggests that management must consciously study workers and employ them in the most fitting job possible. Management should also progressively train workers in their duties to ensure optimal performance (Taylor, 1987: 72; Thurston, 1998: 3).

Action Workout team members are comprised of unit personnel who have varying degrees of expertise in the identified processes, as well as people outside of the organization who are totally unfamiliar with the process. The idea is to get a mixture of people with varying backgrounds to provide fresh, new, differing points of view and enhance creativity. Team members also receive training on AWO concepts, tools, and approaches to improvement. These are indirect examples of the "scientific selection of workers" principle.

The third principle is "Bringing together the science and the man" (Taylor, 1987: 73; Thurston, 1998: 3). In other words, obtain worker cooperation or "buy-in" of scientific principles. Positive incentives, such as better treatment, consideration of wants and needs, and improved communication should be used to infuse worker cooperation, as well as strict negative enforcement of principles. In addition, an environment of rapport and trust between management and lower level workers must be fostered. Management, incidentally, had considerable difficulty coming to terms with this new concept.

Quality Air Force initiatives in general reflect characteristics of this principle. Employee buy-in is an essential element to any change initiative, regardless of title. Unlike scientific management, however, Action Workouts empower workers and utilize them in the improvement process. Also, by relying on worker inputs for improvement ideas, Action Workouts cultivate employee buy-in and consequently stand a better chance for success.

The final principle, "Division of work," was considered an essential characteristic of scientific management (Taylor, 1987: 73-74; Thurston, 1998: 3). Taylor argued that a 50/50 split in work between management and worker would result in teamwork,

democracy, and cooperation. Management must share in the workload by determining the best possible way to do work and providing the worker with all possible means to accomplish their job. Work must be analyzed so that improved methods and tools are provided. Adequate training and equitable feedback should also be given to ensure workers reach their full potential.

To fully appreciate this concept one must consider the history of manufacturing. Just prior to the industrial revolution, manufacturing was done by highly skilled craftsmen who determined what, when, where, and how work was to be done (Schroeder and Robinson, 1991: 68). Change, brought about by the industrial revolution and the advent of sophisticated machinery, diminished the demand for these skilled artisans, and management began to flourish. Management decided how work was to be done and told workers what to do and not to think. Current management philosophies have changed considerably from this strict authoritative management approach, but the notions of teamwork, democracy, and cooperation are considered mainstays. The focal point of both Scientific Management and the Action Workout process is ultimately, process improvement.

Total Quality Management

Total Quality Management (TQM) is arguably the most popular approach to organizational improvement today. The literature surrounding TQM is as plentiful as the number of differing interpretations of the term. In order to establish a conceptual analysis of TQM, it may be helpful to start with a definition of the term. From this a

review of underlying principles and concepts of quality will be made. A leading textbook on quality defines TQM as (Evans and Lindsay, 1996: 103):

> The total, company-wide effort--through full involvement of the entire workforce and a focus on continuous improvement--that companies use to achieve customer satisfaction.

The goals of TQM are to satisfy the customer, prevent--not correct quality problems, develop an attitude of continuous improvement, understand how to effectively measure performance to identify opportunities and maintain improvements, and eliminate sources of inefficiencies and costs (Evans and Lindsay, 1996: 103). The basis of quality management is comprised of personal prescriptions and philosophies from the likes of quality "gurus" such as Deming, Juran, Crosby, Feigenbaum and Ishikawa (Saraph and others, 1989: 810-811; Black and Porter, 1996:1-2). W. Edwards Deming's widely known *14 Points for Continuous Improvement* perhaps best illustrates the TQM concept. The Deming philosophy centers on improving product and service quality through variability reductions in design and manufacturing processes (Evans and Lindsay, 1996: 61). At the time, however, the 14 points were regarded by some as ambiguous and caused confusion among businessmen because they lacked clear rationales (Evans and Lindsay, 1996: 61). Much of the literature surrounding TQM can be directly or indirectly linked to Deming's points. A brief listing of the 14 points is provided in Table 1.

Table 1. Deming's 14 points (Deming, 1986: 23-96)

1. Create constancy of purpose for improvement of product and service
2. Adopt the new philosophy
3. Cease dependence on mass inspection
4. End the practice of awarding business on the basis of price tag alone
5. Improve constantly and forever the system of production and service
6. Institute training
7. Adopt and institute leadership
8. Drive out fear
9. Break down barriers between staff areas
10. Eliminate slogans, exhortations, and targets for the work force
11. Eliminate quotas for the work force and numerical goals for people in management
12. Remove barriers that rob people of pride of workmanship
13. Encourage education and self-improvement for everyone
14. Take action to accomplish the transformation

Throughout the past decade, numerous attempts have been made to decipher and integrate the critical factors of TQM from the myriad papers in the quality literature. In 1989, Saraph and others conducted a thorough review and synthesis of the quality literature to develop an empirical framework based on eight critical factors of quality management (Saraph and others, 1989: 810-11; Black and Porter, 1996: 3-4). Similarly, in 1992, Steel and Jennings identified 11 recurring themes in the TQM literature (Steel and Jennings, 1992: 18-19). In this article, the authors designate TQM as "a family of intervention techniques" (Steel and Jennings, 1992:18). A more recent study done by

Black and Porter identified ten critical factors to be used as an empirical framework of TQM (Black and Porter, 1996: 3-5). The factors are compared in Table 2.

Table 2. Comparison of Total Quality Management Factors

Saraph's 8 Factor Model	Steel and Jennings' 11 Elements of TQM	Black and Porter's 10 Critical Factors of TQM
Top management commitment	Top management commitment	Corporate quality culture Strategic quality management
Quality data and reporting	Measurement bias	Quality improvement measurement systems
Training	Problem-solving training	
Employee relations	Employee empowerment	People and customer management
Process management	Continuous process improvement	Operational quality planning
Product/service design	Quality engineering	External interface management
Supplier quality management	Supplier-relations management	Supplier partnerships
Role of the quality department	Quality policy deployment	Teamwork structures
	Customer relationship management	Customer satisfaction orientation
	Cross-functional problem solving	Communication of improvement information
	Changing the corporate culture	

As depicted in Table 2, similarities exist in nearly every analysis. Clearly, as Black and Porter reported, the major differences lie in the absence of items relating to customer satisfaction and customer relationship management (Black and Porter, 1996: 12). Important similarities that can be linked to the Action Workout process include (1) top management commitment, (2) quality measurement, (3) empowerment, (4) process improvement, and (5) quality policy and teamwork structures.

Another familiar and commonly used source of TQM factors is the Malcolm Baldridge National Quality Award model. The annual U.S. National Quality Award was established when President Reagan signed Public Law 100-107, the Malcolm Baldridge National Quality Improvement Act of 1987. Purposes of the Award are "to promote an understanding of the requirements for performance excellence and competitiveness improvements and to promote sharing of information on successful performance strategies" (Malcolm, 1998). Criteria for the award are provided for business, education, and healthcare, as listed in Table 3.

Table 3. 1998 Malcolm Baldridge National Quality Award Criteria (Malcolm, 1998)

Business	Education	Medical
Leadership	Leadership	Leadership
Strategic planning	Strategic planning	Strategic planning
Customer and market focus	Student and stakeholder focus	Focus on patients, other customers, and markets
Information and analysis	Information and analysis	Information and analysis
Human resource focus	Human resource focus	Staff focus
Process management	Educational and support process management	Process management
Business results	School performance results	Organizational performance results

Quality. Like TQM, the quality construct is difficult to define. In 1984, David A. Garvin conducted a study to synthesize the varying definitions of product quality. He formulated the following 5 approaches to defining quality: (1) transcendent, (2) product-based, (3) user-based, (4) manufacturing-based, and (5) value-based (Garvin, 1984: 25-28). The transcendent approach regards quality as innate excellence. The product- based approach defines quality as a measurable level associated with a product or service attribute. The user-based approach focuses on customer satisfaction. The manufacturing-based approach equates quality to meeting specifications, and the value-based approach measures performance and price (Garvin, 1984: 25-28).

A study conducted at the University of Scranton's School of Management used Garvin's five approaches to investigate how industry managers described quality. Administrators surveyed a group of managers in various industries to help answer the evasive quality question. Respondents were asked to match their definition of quality with one of the following categories cited from Garvin: (1) transcendent, (2) product-based, (3) user-based, (4) manufacturing-based, and (5) value-based (Sebastianelli and Tamimi, 1996:34; Garvin, 1984: 25-28). Not surprisingly, results of the study indicated that, for the most part, the industry in which the respondents were employed greatly influenced their choice of categories.

According to Al Hyde of the Brookings Institution, the cornerstones of quality are process measurement, customer feedback, participative management, and supplier cooperation (Hyde, 1997:58). Dr. David Chaudron synopsizes quality in terms of six elements; focus on quality and prevention of problems, cooperation with suppliers and customers, continuous improvement and waste elimination, empowerment, problem

solving/prevention, and using measurements to back decisions. He defines quality as "consistently producing what the customer wants while reducing errors before and after delivery to the customer," adding that quality is not so much an outcome as it is a never-ending process of continuous improvement (Chaudron, 1998). The Japanese generally regard quality as "anything that can be improved" (Imai 1986: xxiii).

Armand Feigenbaum, renowned quality "guru" and author of the 1983 edition of Total Quality Control, has a different perception of Japanese and American quality. In an interview with Quality Magazine in June 1995, Feigenbaum characterized quality as an American concept that U.S. companies have followed for many years. "The great myth about quality is that it was paced by Japan," said Feigenbaum, adding, "quality is an independent concept that doesn't necessarily vary from industry to industry and country to country" (Litsikas, 1995:38). Feigenbaum contends that the customer defines quality (Litsikas, 1995:38). Feigenbaum's wisdom on quality was so irrefutable that, in 1994, the American Society for Quality Control adopted his interpretation as it's official definition of quality: "Quality is what the customer says it is. It's not what the quality professional says it is. It's not what the engineer says it is. It's what the customer says it is" (Smith and Whitehall, 1997: 42).

By now it should be apparent that there is no single definition of quality or TQM, but rather a conglomeration of concepts, criteria, and categories that can be adapted to fit different scenarios. Many of the quality factors (e.g., management commitment, measurement, empowerment, and process improvement) that appear in the literature must be firmly in place before Action Workout improvement efforts can even be attempted. The fact that senior leaders at Headquarters Air Combat Command have established and

fund an AWO team to assist units at the wing level is just one indication of top management commitment. Process owners and commanders at the wing level must be committed to adopting the AWO philosophy and fostering an environment for continuous improvement. These factors form the foundation from which continuous process improvements can evolve.

Empirical TQM Research. Considering the commonality and stability of the quality movement in the world today, along with the plethora of TQM literature, one would assume that significant empirical evidence exists supporting the TQM construct. This is not the case. Empirical research surrounding TQM is merely just beginning to accumulate (Steel and Jennings, 1992: 31; Black and Porter, 1996: 1; Hendricks and Singhal, 1997: 1259; Sebastianelli and Tamimi, 1998: 161). Most of the TQM literature is based on case studies, "anecdotal evidence" and, as previously mentioned, the personal prescriptions and philosophies of quality gurus describing quality concepts and quality improvement programs (Saraph and others, 1989: 810; Black and Porter, 1996:1-2; Davis, 1997:1; Sebastianelli and Tamimi, 1998: 161). Other research tends to focus on TQM barriers and unsuccessful attempts by organizations to implement TQM (Ahire, 1996: 18; Beer and others, 1990: 158-161; Davis 1997: 13-21; Hyde, 1997: 62-63; Sebastianelli and Tamini, 1998: 161; Sterman and others, 1997: 503-504). Many of the barriers or reasons for unsuccessful TQM efforts are (as reported by Dr. Ahire): "lack of top management commitment, unrealistic expectations about time and cost of implementation, over- or under-reliance on statistical methods, and failure to develop and sustain a quality culture" (Ahire, 1996: 18). Despite initial skepticism, the TQM philosophy seems to be ingrained throughout both the public and private sectors. A

review of empirical research linking quality initiatives with improved organizational performance is provided in the following paragraphs.

Research investigating the effects of Quality Circles (QC), which are small groups of workers from the same work center who periodically meet to discuss, study, and analyze work-related problems (Steel and others, 1990: 365) has produced mixed results. For example, in 1985, Steel and others conducted a longitudinal study to evaluate the success of QC programs at two U.S. Army units. Results of the study showed significant QC benefits for one of the units, while no significant gains were identified at the second unit (Steel and others, 1985: 99). Dr. Steel, and others, conducted a similar study in 1990. The longitudinal study evaluated the effects of QC's on labor-relations criteria in a division of the United States Department of the Treasury. Results of the study showed that QC's at the federal mint had minimal impact on key organizational outcomes. The study did find evidence of QC gains on other evaluation criteria (Steel, and others, 1990: 379).

Richard J. Magjuka developed a survey to examine how manufacturers design and administer employee involvement processes to effectively contribute to continuous improvement objectives. The survey was distributed among 1,000 firms affiliated with the Association for Quality and Participation, a non-profit association that promotes employee involvement programs and total quality improvement in U.S. corporations (Magjuka, 1994: 621). Four key findings of the study suggest that quality performance is enhanced when: (1) teams operate under open and unrestricted information access structures, (2) employees are required to participate in TQM efforts, (3) teams are permanent (as opposed to temporary) task groups, and (4) teams operate within a goal-

setting system (Magjuka, 1994: 626). The study also found that continuous improvement TQM programs were still regarded as relatively new initiatives in many of the firms surveyed (Magjuka, 1994: 626).

In 1991, the United States General Accounting Office (GAO) accomplished one of the more frequently cited empirical studies linking TQM with improved performance. The GAO study was a review of the top 20 applicants for the 1988 and 1989 Malcolm Baldridge National Quality Award. The report indicated that "Companies that adopted quality management practices experienced an overall improvement in corporate performance" (GAO, 1991:2). The study focused on and identified improvements in the areas of employee relations, operating procedures, customer satisfaction, and financial performance (GAO, 1991: 6), and provided robust empirical evidence supporting the implementation of TQM (Sterman et al., 1997: 503-4; Black and Porter, 1996:2).

Thomas J. Douglas reported similar findings in his dissertation at the University of Tennessee in 1997. Douglas developed and used a resource-based perspective model to study the relationship between TQM and organizational performance in the medical services industry, surveying over 500 hospitals in 19 metropolitan areas across the United States. Regression analysis of the 193 responding hospitals indicated that the implementation of TQM was positively related to perceived financial performance, archival return on assets, and quality of service (Douglas, 1997:2).

Thomas C. Powell conducted a review and empirical study of TQM, and it's effects on competitive advantage in 1995. Despite initial criticisms and reported shortcomings associated with instituting TQM, such as excessive increases in cost, paperwork, and time, Powell labeled TQM as an "irrepressible, globally pervasive

strategic force in today's industrial economy" (Powell, 1995: 16). He also referred to the literature encompassing the overall effectiveness of TQM as "unclear and under-examined" (Powell, 1995: 16). Results of the study showed evidence linking TQM with improved operational performance. However, unlike previously cited studies, Powell attributed the improved performance outcomes to "tacit resources," or implied behavioral features of TQM, such as "open culture, employee empowerment, and executive commitment" (Powell, 1995: 15). Furthermore, Powell indicated that many of the TQM tools and techniques, such as quality training, process improvement, and benchmarking, do not lead to enhanced operational performance, or specifically, competitive advantage (Powell, 1995: 15). The author concluded that organizations that acquire these tacit resources can "outperform competitors with or without the accompanying TQM ideology" (Powell, 1995: 15).

Hendricks and Singhal performed a more recent study linking the implementation of TQM with operational performance in 1997. Using quality award winning firms as the basis for the study, Hendricks and Singhal were able to provide "strong evidence that firms that have won quality awards outperform a control sample on operating income-based measures" (Hendricks and Singhal, 1997: 1271). Another important finding of the study indicated that early benefits of TQM programs might outweigh implementation costs (Hendricks and Singhal, 1997: 1271).

Continuous Improvement

While there is no consensus definition of TQM among the "quality gurus," the notion of continuous improvement is prevalent in almost all of the TQM literature.

Continuous improvement is the heart of TQM--one of the single-most important elements of any quality initiative. Deming made a clear distinction between improvement approaches in the East and West (Japanese and US industry) in his book, Out of Crisis. He contended that Japanese companies favor the "gradualist approach" to improvement, while Western companies favor the "great-leap" approach (Deming, 1996: 23-41). The two approaches can be viewed as KAIZEN (gradual), and innovation (great-leap). In Japan, improvement is defined as KAIZEN *and* innovation (Imai, 1986: xx). KAIZEN is instilled as "a mindset inextricably linked to maintaining and improving standards." KAIZEN strategy maintains and improves standards by implementing minute, gradual improvements. Innovation, on the other hand, brings about radical improvements as a result of technological advancements or equipment investments (Imai, 1986: xx). Deming similarly described KAIZEN as undramatic, subtle, continuous improvement that could be characterized as people-oriented. He described innovation as a dramatic, one-shot phenomenon characterized as technology and money-oriented (Deming, 1996: 23-41). From this it can be said that a successful continuous improvement effort must exhibit both KAIZEN and innovation approaches.

Quality Air Force attempts to instill both approaches in the pursuit of continuous improvement. For example, Air Force policy dictates that commanders follow specific operating styles to foster an environment conducive to continuous improvement. These operating styles can be viewed as KAIZEN strategy (Bernowski, 1994: 26):

- Create a working climate that inspires trust, teamwork, and pride.
- Delegate responsibility and authority, and accept accountability for results.
- Set goals, measure progress, and reward performance.
- Give everyone a stake in the outcome.

Action workouts, by definition, are employed to bring about "dramatic productivity improvements in any organization" (DoD, 1996b: 41-45). Obviously, an AWO event can be considered as an innovation approach to improvement.

Successful Continuous Improvement. Much of the continuous improvement literature emphasizes the importance of rank and file worker involvement in improvement efforts. (Suzaki, 1993: 87-116; Imai, 1996: 217; Choi and others, 1997: 45). Action Workouts epitomize this concept by relying on worker inputs during the AWO process. Process owners attack waste and create innovative ideas while being assisted by AWO team leaders, headquarters functional policy experts, engineers, and technical order specialists. The supporting cast is available to provide guidance, clear obstacles, and make on the spot changes to written procedures (AWO, 1997). Worker involvement, however, is not the only contributing factor for successful improvement initiatives. Schroeder and Robinson (1991) proposed four fundamental principles for successful continuous improvement initiatives (Shroeder and Robinson, 1991: 74-79). First, *"It must be clearly understood that improvements at first cause dislocation, and almost always require time before they prove worthwhile."* In other words, new procedures brought about by continuous improvement programs are generally more difficult and time-consuming than the familiar "old" procedures. For this reason, improvements require a certain amount of time or learning period before true effects can be realized. Second, *"Operating practices that restrict the flow of ideas must be eliminated."* Organizational culture should encourage close relationships between management and workers and eliminate barriers to communication. Employment guarantees and incentive programs also help to encourage creative thinking and idea

generation. Third, *"Employees must be continuously trained and developed, particularly in techniques of methods improvement."* Employee development is more than teaching people how to do their job. Problem solving techniques must be taught so employees can improve the methods by which their work is done. Finally, *"A continuous improvement effort needs an efficient mechanism to handle improvement ideas."* A continuous improvement program must have well-planned means to gather, evaluate, implement, and reward improvement ideas. Effective suggestion programs should exhibit the following characteristics. They should be simple to participate in, and encouraged. Competent parties, who should provide employees rapid feedback, should review all ideas. Approved ideas should be implemented as quickly as possible.

These principles obviously relate to the Action Workout improvement process, and seem to be well established in the Air Force's quality culture today. The true test will be the sustainment of continuous improvement initiatives through the long-term.

Change

With almost every improvement there exists change. Not every change, however, results in improvement (Provost and Langley, 1998: 31, Provost and Sproul, 1996: 101). A recent study conducted by Coopers and Lybrand Consulting, in conjunction with Opinion Research International, identified the following five key elements to successfully initiating change in the workplace: (1) strong leadership, (2) effective communication, (3) a tight alignment of people and organizations, (4) adequate training and funding, and (5) clear definition of compelling reasons to change (Smith, 1998: 45-48). These key elements apply to both large-scale (organizational-level) and small-scale (transactional-

level) changes. Other literature suggests full and open communication, building trust, and encouraging a culture of change (Barrier, 1998: 31-34; Suzaki, 1983: 16-40).

The principles of effective change are similar to the principles of continuous improvement and are equally important to the overall success of Action Workouts in the Air Force today.

Summary

The literature surrounding Scientific Management, Total Quality Management, and Continuous Improvement were explored to provide a basis for this research effort. While many of the concepts discussed are difficult to grasp absolutely, the major principles can be directly or indirectly associated with the Action Workout process. The following chapter will explain the method used in this study.

III. Method

Overview

The objective of this study is to gather and analyze aircraft inspection data to determine if quality enhancements are realized after an action workout is accomplished. In order to achieve this objective, an appropriate research design and data analysis method were required. This chapter will discuss the method used to achieve the research objective.

Sampling Design

The target population of interest to this study consists of all Air Combat Command units that have had an Action Workout accomplished on one or more critical processes. At the beginning of this research effort, twenty processes were identified as having been subjected to the AWO improvement method. Eight of the identified twenty AWO events were accomplished on major aircraft inspection processes. These processes were chosen as the target population for a variety of reasons. First, a major aircraft inspection process is crucial to operational readiness and to the mission of the Air Force. Second, the process is relatively complex and provided a multitude of improvement opportunities. Finally, the necessary data or process measurements were obtainable and provided for useful analysis.

Research Design

The ex post facto research design, utilizing pretest and post-test data, was chosen as the most feasible approach for this study. The scope of this research, along with budget

and time constraints, made it nearly impossible to conduct an experimental study that would provide a more powerful evaluation of the AWO process. Although manipulation of variables could not be made, the ex post facto design, when used with caution, can still provide sufficient evidence of causation (Cooper and Emory, 1995: 142). While the focus of the study is to determine whether a causal relationship exists between Action Workout's and the overall quality of the processes studied, it is imperative to note that multiple causes may, and most likely do, exist. These causes or extraneous variables will be addressed in the following chapters.

To ensure that an adequate sample size could be obtained, careful consideration was given to the timing of each AWO event. Since the frequency of inspections varied according to weapon system, it was determined that approximately two years of data would be sufficient. The goal was to obtain 12 months of data both *before* and *after* the date of the AWO event, so that comparisons could be made. Three units were selected that closely met these criteria:

1. 55 WG, Offutt AFB, NE. C-135 Isochronal Inspection Process
2. 552 ACW, Tinker AFB, OK. E-3 Isochronal Inspection Process
3. 355 WG, Davis Monthan AFB, AZ. A-10 Phase Inspection Process

Measures

The data used in this study were archival process measures, or more specifically, Quality Verification Assessment results formulated by Quality Assurance personnel. As previously mentioned, a Quality Verification Assessment is a follow-up inspection/assessment of an item (equipment) or process (maintenance or repair action) performed to determine "an estimate of quality, relative to a predetermined level of

expected or acceptable status" (DoA, 1997: 135). The measure of whether an assessment was acceptable or unacceptable is described as a Quality Verification Result (QVR). The QVR is based on Acceptable Quality Levels established by Quality Assurance personnel. There are three QVR categories: A QVR 1 indicates that the Acceptable Quality Level was met, a QVR 2 indicates that the Acceptable Quality Level was not met, and a QVR 3 indicates that the Acceptable Quality Level was not met due to a safety or serious (major) defect (DoA, 1997: 138). A brief explanation of Quality Assurance is given to provide a better understanding of the data source.

Quality Assurance. Quality Assurance can be described as a separate unit comprised of a variety of personnel with differing maintenance specialties. The role of Quality Assurance, according to ACCI 21-101, is to assess, analyze, and identify problems in Wing maintenance areas; assess the quality of training; determine aircraft and equipment condition; and increase reliability and maintainability. Quality Verification Assessments are only one of many elements that make up Quality Assurance Program's, which are designed to improve combat capability through high quality maintenance and effective maintenance training (DoA, 1997: 127). According to ACCI 21-101, Quality Assurance is required to perform a Quality Verification Assessment (follow-up) of every major aircraft inspection to verify that the inspection was properly accomplished (DoA, 1997: 128). All discrepancies noted during the Quality Verification Assessment are documented, and entered into the Quality Assurance database. Discrepancies are classified as either major or minor defects. Defects that may lead to severe damage to equipment or injury to personnel are classified as major defects. A

minor defect is a missed or incomplete inspection item that will not result in excessive damage to equipment or safety of flight.

To obtain a representative sample of inspection results, Quality Verification Assessment data was collected from three separate Quality Assurance inspection teams who conduct maintenance assessments/inspections on the A-10, C-135, and E-3 weapon systems at the 355 WG, Davis Monthan AFB, AZ., the 55 WG, Offutt AFB, NE., and the 552 ACW, Tinker AFB, OK., respectively. The three teams were chosen primarily because of the availability of data and represent a wide array of inspection requirements and improvement opportunities.

55 WG, Offutt AFB, NE. C-135 Isochronal Inspection Process. The Quality Assurance databases provided QVR ratings, overall Quality Assurance scores, and total number of inspection days per aircraft. Acceptable Quality Levels established the QVR ratings. Adding the points associated with minor and major defects noted during the assessment derived overall scores. In all cases, one point is given for each minor defect, and four points for each major defect. For example, a Quality Verification Assessment that identified two minor defects, and one major defect, would have an overall score equal to six. Data was collected on 82 Quality Verification Assessment's conducted between February 1996, and October 1997. The data was then split to form the pretest and post-test data sets. The number of assessments accomplished before the AWO was 23, while the number accomplished after the event was 59.

552 ACW, Tinker AFB, OK. E-3 Isochronal Inspection Process. In addition to QVR ratings and overall scores, the 552nd Quality Assurance databases provided the number of major and minor defects that were found during each assessment. Data

reflecting total inspection days per aircraft could not be obtained. The total sample size was 75. The data was then split to form pretest and post-test data sets. The number of assessment's accomplished before the AWO event was 9, while the number accomplished after the event was 66.

355 WG, Davis Monthan AFB, AZ. A-10 Phase Inspection Process. The 355th Quality Assurance databases contained information similar to that of the 552nd Quality Assurance. Data reflecting total inspection days per aircraft could not be obtained. The total sample size was 86. The data was also split to form pretest and post-test data sets. Twenty-four assessments were accomplished before the AWO event, and sixty-two after.

Once again, it is important to note that data analyzed for this study was obtained from Quality Verification Assessments, conducted by Quality Assurance personnel. Maintenance personnel assigned to their respective Inspection Sections accomplished the actual Phase and Isochronal inspections.

Procedure

Archival assessment data were obtained from databases maintained by each unit. In all three cases, the amount of useful data reflecting process measures prior to the AWO interventions (henceforth the pretest scores) were fewer than the data reflecting process measures after the AWO interventions (henceforth the post-test scores). This anomaly can best be attributed to advances or changes in the information management systems used by the units. Changes in maintenance inspection concepts (phase to isochronal) also contributed to these shortfalls, particularly at Tinker AFB, OK. In addition, the type of

information, as well as the level of detail, varied between Quality Assurance databases at the three selected units (55 WG, 355 WG, and 552 ACW). For example, the 55 WG was the only unit with inspection time data and the only unit not to have data pertaining to the number of major and minor defects. Because the data were not aggregated across samples, metric differences were not an analytic problem.

Data Analysis

In order to improve the reliability of the study, pretest and post-test assessment data from similar processes performed at three separate units were analyzed. Descriptive statistics were used to identify means, variances, and standard deviations. Parametric t-tests were then used to determine the significance of any differences between the sample means (Quality Assurance scores, majors, and minors), as applicable. Chi-square analysis was used to determine differences between QVR ratings. The data are free from selection bias and independent.

IV. Results

Overview

This chapter reports findings and differences between pretest and post-test data samples for three separate units. A brief synopsis of each unit's Action Workout trip report is provided as supplemental information only. Action Workout trip reports for the units identified in this study, as well as every Air Combat Command unit that hosted an event, can be obtained from the Air Combat Command Quality and Management Innovation Squadron's internet homepage (Action, 1997). The independent results are provided in the following three sections: Offutt Results, Davis-Monthan Results, and Tinker Results.

Offutt Results

Offutt AFB pretest and post-test data sets reflecting QVR ratings, mean Quality Assurance scores, and total number of inspection days per aircraft were analyzed.

AWO Summary. The Action Workout effort on the C-135 Isochronal inspection process was accomplished during the week of 29 July through 2 August 1996. Due to the limited number of mission-critical aircraft, a requirement existed to return aircraft to fully mission capable status as quickly as possible. The urgent need for improvement stemmed from the unacceptable number of days required to perform an inspection--approximately eight days per aircraft. To complicate matters, maintenance personnel assigned to the Inspection Section were responsible for performing inspections on 13 different models of C-135 aircraft. Five teams were assembled to focus on critical paths identified during the AWO team visit (pre-work). Each team implemented numerous innovations and

improvement ideas that resulted in impressive reductions in all target areas: set-up time, man-hours, cycle-time, and distance traveled. For example, the wing inspection team reported a 72% reduction in cycle time and an 89 % reduction in distance traveled for the wing inspection portion of the process. The lubrication team reported a 61% reduction in cycle-time and man-hours required to lubricate an aircraft, as well as an 88% reduction in distance traveled. Eliminating, streamlining and changing technical order inspection requirements brought about many of the improvement results. Other innovations, such as the repositioning of tools and equipment, designing of tool belts and parts bags, and acquisition of special equipment, also contributed to the overall savings. In the end, the entire C-135 isochronal inspection process was reportedly reduced to an average of "just over 6 days" (Action, 1997).

Table 4. Offutt AFB QVR Ratings

	Pretest[a]		Post-test[b]		X^2
Variables	Freq	%	Freq	%	*(df)*
QVR 1	13	56.50	49	83.10	6.32* 1
QVR 3	10	43.50	10	16.90	

[a] $N = 23$

[b] $N = 59$

* $p < .05$

QVR Ratings. Table 4 illustrates the frequency and percentage of both QVR 1 and QVR 3 ratings that complete the pretest and post-test data sets at Offutt AFB. Pretest data indicated that 13 of 23 inspections (56.5%) received QVR 1 ratings and 10

inspections (43.5%) received QVR 3 ratings. Post-test data showed 49 QVR 1 ratings (83.1%) and 10 QVR 3 ratings (16.9%). There were no QVR 2 ratings in either data set. Results indicate a 26.6% increase in the number of QVR 1 ratings received after the AWO intervention. Nonparametric chi-square analysis indicated the difference between pretest and post-test QVR ratings was statistically significant ($X^2 = 6.3156$, $df = 1$). The QVR rating, otherwise referred to as the "pass/fail rating," is the primary, bottom line performance measure used in many aircraft maintenance processes today. Other performance measures used in this study, such as score, major, and minor defects, ultimately contribute to the QVR rating, but do not receive the same amount of scrutiny. In terms of process improvement, the 26.6% increase in QVR 1 ratings realized at Offutt AFB is substantial. The following table illustrates pretest and post-test mean Quality Assurance scores.

Table 5. Offutt AFB Quality Assurance Scores

	Pretest[a]			Post-test[b]			
Variable	Mean	S.D.	Variance	Mean	S.D.	Variance	T-stat
Score	12.87	5.70	32.48	9.86	6.32	39.91	*-1.99

[a] $N = 23$

[b] $N = 59$

* $p < .05$

Quality Assurance Scores. Recall from the previous chapter that overall Quality Assurance scores are derived by adding the points associated with the number of major (four points) and minor (one point) defects noted during the Quality Verification

Assessment. Data analysis indicates that, on average, fewer discrepancies are being found during follow-up assessments at Offutt AFB since the AWO intervention. The mean score for the pretest data set was 12.9. The mean score for the post-test data set was 9.9. Results indicate a 23.3% reduction (3 points) in overall score. T-test analysis for two independent samples confirmed the difference between mean scores was statistically significant (p=.0504). Considering the complexity of the C-135 isochronal inspection process, a three-point reduction is noteworthy.

Table 6. Offutt AFB Inpsection Days

	Pretest[a]			Post-test[b]			
Variable	Mean	S.D.	Variance	Mean	S.D.	Variance	T-stat
Days	7.65	1.07	1.15	7.76	1.30	1.70	0.36

[a] $N = 23$

[b] $N = 59$

Inspection Days. One of the primary objectives of an Action Workout is to cut process cycle times. As mentioned above, the AWO team reported an expected 1.5-day reduction per isochronal inspection. These estimates, however, were based on a single event. Statistical analysis of the pretest and post-test data sets revealed that there was no significant difference between pretest and post-test inspection times (see Table 6). The average number of days required to perform an inspection prior to the AWO intervention was 7.7, compared to 7.8 days required after the intervention.

Davis-Monthan Results

Pretest and post-test data sets for Davis Monthan AFB reflect mean QVR ratings, Quality Assurance scores, and number of major and minor defects noted per inspection.

AWO Summary. The Action Workout on the A-10 phase inspection process took place between 19 May and 23 May 1997. Five teams were also formed to narrow the focus of the event. Substantial improvements were reported by eliminating unnecessary process steps, consolidating equipment, reducing travel distance, and incorporating a revised inspection process and phase schedule. Some notable improvement results include cycle time and man-hour savings of 41%, for portions of the "look phase" inspection, as well as a 65% reduction in distance traveled. The structural repair team reported an 82% reduction in cycle-time and man-hours required for corrosion inspections. The total process cycle time for the A-10 phase inspection process reportedly dropped from 75 to 48 hours, a 36% decrease (Action, 1997).

Table 7. Davis Monthan AFB QVR Ratings

	Pretest[a]		Post-test[b]		X^2
Variables	Freq	%	Freq	%	*(df)*
QVR 1	14	58.30	34	54.80	0.09 1
QVR 3	10	41.70	28	45.20	

[a] $N = 24$

[b] $N = 62$

QVR Ratings. Table 7 illustrates Davis Monthan AFB QVR ratings. Pretest data indicated that 14 of 24 inspections received a QVR 1 rating (58.3%), and 10 inspections received QVR 3 ratings (41.7%). Post-test data showed 34 QVR 1 ratings (54.8%) and 28 QVR 3 ratings (45.2%). There were no QVR 2 ratings in either data set. Results indicate a 3.5% decrease in the number of QVR 1 ratings received after the AWO intervention. This slight decrease, however, was not found to be significant.

Table 8. Davis Monthan AFB Quality Assurance Scores

	Pretest[a]			Post-test[b]			
Variable	Mean	S.D.	Variance	Mean	S.D.	Variance	T-stat
Score	5.29	5.92	35.00	6.69	6.04	36.48	-0.98

[a] $N = 24$

[b] $N = 62$

Quality Assurance Scores. Table 8 shows pretest and post-test Quality Assurance scores for Davis Monthan AFB. The mean score for the pretest data set was 5.3. The mean score for the post-test data set was 6.7. Results indicate a 20.9% increase in overall score. T-test analysis for two independent samples indicated that the difference between mean scores was not statistically significant (p=.3326). Table 9 shows the pretest and post-test data for major and minor defects.

Table 9. Davis Monthan AFB Major and Minor Defects

	Pretest[a]			Post-test[b]			
Variable	Mean	S.D.	Variance	Mean	S.D.	Variance	T-stat
Major	0.67	1.67	1.36	0.63	1.01	1.02	0.15
Minor	2.63	2.20	4.85	4.18	3.66	13.39	* -2.40

[a] $N = 24$

[b] $N = 62$

* $p < .05$

Major Defects. Virtually no significant difference was found between the mean number of major defects in the pretest and post-test data sets. As Table 9 indicates, the average number of major defects found per inspection prior to the AWO intervention was .7, compared to .6 after the AWO intervention.

Minor Defects. The difference between the mean number of minor defects in the pretest and post-test data sets, however, was statistically significant. The average number of minor defects found per inspection prior to the AWO intervention was 2.6, compared to 4.2 minor defects found after the AWO intervention, resulting in a 36.5% increase. The increase in minor discrepancies (1.6) found during follow-up assessments conducted after the AWO intervention are indicative of the trends in the process measures listed above (QVR ratings, score).

Tinker Results

Pretest and post-test data sets for Tinker AFB also reflect mean QVR ratings, Quality Assurance scores, and number of major and minor defects noted per inspection.

Consideration must be given to the number of samples that comprise the data sets. As previously mentioned, the number of pretest samples (9) is considerably less than the number of post-test samples (66). Baseline estimates of pretest quality may, as a consequence, be somewhat imprecise.

AWO Summary. The Action Workout effort on the E-3 Isochronal inspection process occurred from 4 November to 8 November 1996. The critical need to improve the unit's E-3 isochronal inspection process at Tinker was difficult to ascertain due to two dramatic yet unrelated process changes that took place prior to the AWO event. The unit had already realized significant improvements in aircraft maintenance down time by changing the maintenance inspection concept from phase to isochronal and through the acquisition and implementation of maintenance scaffolding. The phase to isochronal conversion process enabled the unit to reduce non-mission capable time by 120 days per year. The use of scaffolding enabled the Wing to eliminate 294.8 hours per phase inspection. When the AWO team arrived at Tinker AFB on 8 Nov, the E-3 isochronal inspection process took approximately 4.2 days. After conferring with process owners, five teams were assembled to focus on the critical path tasks that offered the best opportunities for further improvement. Once again, eliminating unnecessary process steps, consolidating equipment, reducing travel distance, and revising work sequences generated significant results. According to the AWO team chief, enthusiasm, and a "can-do" spirit was displayed by everyone involved, including senior leadership. This top level commitment and employee "buy-in" are deemed as equally important to the AWO improvement effort as the improvement ideas and innovations created by team members.

The report indicated that a full day was eliminated from the E-3 inspection process (Action, 1997).

Table 10. Tinker AFB QVR Ratings

	Pretest[a]		Post-test[b]		X^2
Variables	Freq	%	Freq	%	*(df)*
QVR 1	3	37.50	46	76.70	*5.38 1
QVR 3	5	62.50	14	23.30	

[a] $N = 8$

[b] $N = 60$

* $p < .05$

QVR Ratings. Table 10 illustrates the frequency and percentage of only the QVR 1 and QVR 3 ratings that complete the pretest and post-test data sets at Tinker AFB; QVR 2 ratings are not shown. Pretest data indicated that 3 of 9 inspections received a QVR 1 rating (33.3%), 1 inspection received a QVR 2 rating (11.1%), and 5 inspections received QVR 3 ratings (55.6%). Post-test data showed 46 QVR 1 ratings (69.7%), 6 QVR 2 ratings (9.1%) and 14 QVR 3 ratings (21.2%). In using the chi square analysis, the pretest QVR 2 rating produced an expected value of .84. Since the expected value was less than one, the chi-square analysis could not be performed properly (Cooper and Emory, 1995: 452-453). Therefore, all QVR 2 ratings were removed from further analysis. Results indicate a 39.2% increase in the number of QVR 1 ratings received after the AWO intervention. Chi-square analysis indicated that the difference between

QVR ratings was statistically significant ($X^2 = 5.3782$, $df = 1$). The increase in QVR 1 ratings is substantial.

Table 11. Tinker AFB Quality Assurance Scores

	Pretest[a]			Post-test[b]			
Variable	Mean	S.D.	Variance	Mean	S.D.	Variance	T-stat
Score	8.89	5.97	35.61	4.63	4.26	18.14	*-2.67

[a] $N = 9$

[b] $N = 66$

* $p < .05$

Quality Assurance Scores. The mean score for the pretest data set was 8.9. The mean score for the post-test data set was 4.6. Results indicate a 48.3% decrease in overall score. T-test analysis for two independent samples indicated that the difference between mean scores was statistically significant (p=.0093). The increase in Quality Assurance scores, as shown in Table 11, is also substantial.

Table 12. Tinker AFB Major and Minor Defects

	Pretest[a]			Post-test[b]			
Variable	Mean	S.D.	Variance	Mean	S.D.	Variance	T-stat
Major	1.00	1.12	1.25	0.35	0.75	0.57	-1.70
Minor	4.89	2.15	4.61	3.24	0.35	8.25	-1.65

[a] $N = 9$

[b] $N = 66$

Major Defects. Prior to the AWO intervention, an average of 1 major defect was found per inspection, compared to .4 major defects found per inspection after the intervention (see Table 12). Although results indicated a decrease, the difference between the mean number of major defects in the pretest and post-test data sets was not significant.

Minor Defects. The average number of minor defects found per inspection prior to the AWO intervention was 4.9, compared to 3.2 minor defects found after the intervention, resulting in a 34.7% decrease. Again, the difference was not significant.

Summary

Favorable results or, indications of improvement, were found in nearly all inspection process measures at Tinker AFB and Offutt AFB. Quality Assurance scores and QVR ratings at these two units showed significant differences between pretest and post-test data sets. Comparatively, Davis Monthan AFB yielded opposite trends in every process measure except for the number of major defects. However, the data indicated that differences among these process measures were not statistically significant. The only significant difference was the increase in the number of minor defects found by Quality Assurance after the AWO intervention. This signifies that, on post AWO inspections, inspection section maintenance personnel are failing to identify approximately 1.6 (36.5%) fewer minor defects than were found prior to the AWO intervention.

V. Conclusion

Overview

The objective of this study was to gather and analyze aircraft inspection data to determine if quality enhancements were realized after an Action Workout was accomplished. Three units were identified as having major aircraft inspection processes improved by the AWO concept. Pretest and post-test assessment data from the units were analyzed to determine whether overall quality improvements were made.

This study operationally defined quality in terms of Quality Verification Assessment ratings compiled before and after each AWO event. The Quality Verification Assessment criteria used in this study were QVR ratings, Quality Assurance scores, and the number of major and minor defects found by Quality Assurance inspectors during follow-up assessments of inspection section personnel. Comparisons were made to determine if ratings improved, declined, or remained unchanged. Parametric t-tests were used to determine the significance of any differences between the sample means (Quality Assurance scores, majors, and minors), as applicable, and nonparametric chi-square analyses were used to determine differences between QVR ratings. This chapter will provide a summary and discussion of findings, highlight limitations, and recommend future research directions.

Summary and Discussion

This study investigated whether drastic process improvements brought about by Action Workouts have any effect on process quality as a whole. Overall, the results provide at least plausible evidence suggesting that quality enhancements can be realized

as a result of Action Workouts. Results at two of the three units analyzed indicate that overall quality of major aircraft inspection processes improved considerably, quite possibly as a result of the Action Workout intervention. QVR ratings (considered as the most relevant process measure) and overall Quality Assurance scores dramatically improved at both Offutt AFB (26.6% increase) and Tinker AFB (39.2% increase), but remained essentially unchanged at Davis Monthan AFB (3.5% decrease). The "dramatic" increases at Offutt and Tinker AFB's were found to be statistically reliable.

The evidence also suggests that many of the changes and innovative process improvement ideas reported by the Air Combat Command Quality and Management Innovation Squadron are seemingly intact and being utilized by respective maintenance personnel at Offutt AFB and Tinker AFB. This is important in that it indicates acceptance of change, and employee "buy-in, " two essential principles of quality improvement. It may also be inferred that leadership commitment exists at these two units. This is not to say that this "quality culture" is lacking at Davis Monthan AFB, but rather, the available data made it difficult to make any inferences whatsoever.

Virtually no significant difference was found between the mean number of major defects in the pretest and post-test data sets at Tinker AFB and Davis Monthan AFB. Evidence showed decreasing trends, however, at both units.

The only statistically reliable difference that indicated a *decline* in quality was found in the minor defect samples at Davis Monthan AFB. An increase in the number of minor defects were found when comparing pretest and post-test data sets. Essentially, on post-AWO inspections, Davis Monthan maintenance personnel were failing to identify an average of 1.6 minor defects *fewer* per phase inspection than they did prior to the AWO

intervention. This statistically significant difference is congruent with the trends in both Quality Assurance scores and QVR ratings, but is not considered to be substantial. It is possible that some of the changes brought about by the AWO either hampered the inspection process, or some changes may not have been fully integrated into the process. The available data does not provide explanations for this downward trend.

Limitations

The ex-post facto research design, along with the limited amount of pretest and post-test data, provided weak scientific measurement power for this study. Several threats to both internal and external validity exist (Cooper and Emory, 1995: 358-361). In interpreting the results of this study, it must be noted that many extraneous variables exist that may conceivably affect the relationship between AWO's and process quality, further lessening the support for causality. A crucial limitation of this study was that available data provided little insight for determining explanations for relational effects that were found.

This study did not examine self-report variables, such as experience, proficiency, job satisfaction, or stress. Experience and proficiency of maintenance personnel, both of which contribute to job performance measures or "quality" of work, may have changed over the period of the study. Similarly, the experience and proficiency of the Quality Assurance personnel who performed the assessments may have also changed. Generally, an experienced and technically competent evaluator will be able to identify more discrepancies while doing an assessment than an evaluator of lesser proficiency and experience. The effects of job-satisfaction, morale, and stress may have also changed

over the study time period. Although force drawdowns have somewhat stabilized over the past year in the Air Force, the operations tempo continues to escalate. This increased "ops tempo" undoubtedly affects overall job performance, morale, and stress, especially in the maintenance field.

This study was also limited by the amount of variables used to define the quality construct. This study used available archival assessment data as the only measure of quality. With the exception of inspection days, the assessment measures were nonorthogonal. For example, the number of defects found during an assessment determines the score, and the score determines the QVR rating. Supplemental measures, such as customer satisfaction data and aircraft reliability statistics, might improve the scientific measurement power of this study.

As previously mentioned, historical process data (man-hours, cycle time, distance traveled, etc.,) were virtually nonexistent, except for the data reported in the applicable AWO trip reports. Therefore, it was difficult to ascertain specific reasons for any relationships that were identified.

Yet another limitation of this study was that it focused on an extremely complex process--major aircraft inspections. Analysis of less complicated processes that have undergone AWO interventions may yield more powerful results. These limitations also make it difficult to generalize results.

Suggestions for Future Research

To the best of my knowledge this is the only study that has explored the ramifications of Action Workout's. Albeit limited, this study has set the foundation for

further research in this area. Further research is important so that Air Force leaders are able to make informed decisions about how best to utilize this improvement tool.

As previously mentioned, future studies assessing the effectiveness of AWO's are necessary. Longitudinal studies could be made to assess AWO process measures, such as cycle time, distance-traveled, and man-hours. This is crucial for the Air Force because the studies might provide better insight as to what "works," what doesn't work, and more importantly, *why*. It would also indicate whether AWO improvement ideas and innovations remained in effect over extended time periods.

Another follow-on study may attempt to evaluate the overall quality culture in similar pretest, post-test scenarios. This may further support causal inference between AWO's and their overall effectiveness.

Conclusion

According to the Air Combat Command 1998 Strategic Plan, the two major challenges facing Air Combat Command are a high operations tempo and operating in a "fiscally austere environment" (Action, 1997). Specific goals were identified by senior leaders to meet these challenges head-on. One of the goals for ACC is to reduce operating costs by 30 %. Action Workouts, designed to achieve savings in manpower and time, have been identified as one of the primary means for achieving this goal. This study has established some plausible evidence that, in addition to the reported manpower and time savings, Action Workouts may enhance overall process quality. The implications for the Air Force are critical in that continuous improvement initiatives are essentially becoming the means for "operationalizing quality" in the Air Force today.

Bibliography

"Action Workout." Air Combat Command Quality and Management Innovation Squadron, n.pag. WWWeb, http://www.acc.af.mil/qi/.htm. (October 1997).

Ahire, Sanjay L. "TQM Age Versus Quality: An Empirical Investigation," Production and Inventory Journal, 37: 18-23 (1996).

Barrier, Michael. "Managing Workers In Times Of Change," Nations Business, 86: 31-34 (May 1998).

Beer, Michael and others. "Why Change Programs Don't Produce Change," Harvard Business Review, 158-167 (November-December 1990).

Bernowski. "The Air Force Quality Flight Plan," Quality Progress, 25-29 (June 1994).

Black, Simon A. and Leslie J. Porter. "Identification of the Critical Factors of TQM," Decision Sciences, 27: 1-16 (Winter 1996).

Chaudron, David. "Elements of Quality." n.pag. WWWeb, http://www.organizedchange.com/tgmelem.htm. (March 98).

Choi, Thomas Y. and others. "Continuous Improvement on the Shop Floor: Lessons From Small to Midsize Firms." Business Horizons, 45-50 (November-December 1997).

Cooper, Donald R. and William C. Emory. Business Research Methods. (Fifth Edition). Chicago IL: Richard D. Irwin, Inc., 1995.

Davis, Tim R. V. "Breakdowns in Total Quality Management: An Analysis With Recommendations," International Journal of Management, 14: 13-22 (March 1997).

Deming, W. Edwards. Out of the Crisis. Cambridge MA: MIT, Center for Advanced Engineering Study, 1986.

Department of the Air Force (DoA). Objective Wing Aircraft Maintenance. ACCI 21-101. Washington: HQ USAF, 1997.

-----. Standardizing Action Workout Events. ACCI 90-553. Washington: HQ USAF, 1996.

Department of Defense (DoD). Aircraft, Drone, Aircrew Training Devices, Engines, and Air-Launched Missile Inspections, Flight Reports, and Supporting Maintenance Documents. TO 00-20-5. Washington: GPO, 1 June 1996.

-----. The Quality Approach. AFH 90-502. Washington: GPO, 1 August 1996.

Douglas, Thomas J. "Adopting a Total Quality Strategy For Competitive Advantage: A Resource-Based Evaluation." Ph.D. dissertation. University of Tennessee. Dissertation Abstracts International, 58-09: 3603 (1997).

Evans, James R. and William M. Lindsay. The Management and Control of Quality. (Third Edition). St Paul: West Publishing Company, 1996.

G.A.O. Management practices: U.S. companies improve performance through quality efforts. Washington DC: General Accounting Office, GAO/NSIAD-91-190, (1991).

Garvin David A. "What Does 'Product Quality' Really Mean?" Sloan Management Review, 25-43 (Fall 1984).

Hawley, Richard E. General, Commander, Air Combat Command. "Applying Technology and Innovation in Operational Settings." n.pag. WWWeb, http://www.af.mil/news/speech/current/Applying_Technology_and_Inn.html. Delivered at the Quality Air Force in the 21st Century: Technology and Innovation Symposium. Montgomery AL, 16 October 1996.

Hendricks, Kevin B. and Vinod R. Singhal. "Does Implementing an Effective TQM Program Actually Improve Operating Performance? Empirical Evidence From Firms That Have Won Quality Awards," Management Science, 43: 1258-1274 (September 1997).

Hickey, Amy. "Action Workouts cut waste, improve processes." Air Force News, n.pag. WWWeb, http://www.af.mil/news/Oct1997/n19971017_971319.html. (October 1997).

-----. "Action Workouts save command $24 million during '97." Air Force News, n.pag. WWWeb, http://www.af.mil/news/Dec1997/n19971224_971642.html. (December 1997).

Hyde, Al. "A Decade of Quality Management," Government Executive, 58-68 (July 1997).

Imai, M. Kaizen: The Key to Japan's Competitive Success. New York: Random House, 1986.

Litsikas, Mary. "No One Can Afford to Buy Cheap Anymore," Quality, 37-40 (June 1995).

Magjuka, Richard J. "Employee Involvement and Continuous Process Improvement (TQM): An Empirical Study." International Journal of Management, 16: 15-37 (1995).

"Malcolm Baldridge National Quality Award," National Institute of Standards and Technology, n.pag. WWWeb http://www.quality.nist.gov. (July 1998).

Powell, Thomas C. "Total Quality Management as Competitive Advantage: A Review and Empirical Study." Strategic Management Journal, 16: 15-37 (1995).

Provost, Lloyd P. and Gerald J. Langley. "The Importance of Concepts in Creativity and Improvement," Quality Progress, 31-37 (March 1998).

Provost, Lloyd P. and R. M. Sproul. "Creativity and Improvement: A Vital Link," Quality Progress, 101-107 (August 1996).

Saraph, Jayant V., George P. Benson, and Roger G. Schroeder. "An Instrument for Measuring the Critical Factors of Quality Management," Decision Sciences, 20: 810-822 (1989).

Sebastianelli, Rose and Nabil Tamimi. "How Firms Define and Measure Quality." Production and Inventory Management Journal, 34-39, (Third quarter, 1996).

Shroeder, Dean M. and Alan G. Robinson. "America's Most Successful Export to Japan: Continuous Improvement Programs," Sloan Management Review, 67-79 (Spring 1991).

Smith, Dick. "Initiating Change Initiatives," Management Review, 87: 45-48 (May 1998).

Smith, James A. and Frank Whitehall. "In Search Of Quality, It's really dependability we're after." Machine Design, 69: 41-48 (September 1997).

Steel, Robert P. and others. "Factors Influencing Success and Failure of Two Quality Circle Programs." Journal of Management, 11: 99-119 (1985).

Steel, Robert P. and others. "Quality Circle Problem Solving and Common Cents: Evaluation Study Findings From a United States Federal Mint." The Journal of Applied Behavioral Science, 26: 365-381 (1990).

Steel, Robert P. and Kenneth R. Jennings. "Quality Improvement Technologies for The 90s: New Directions for Research and Theory," Research in Organizational Change and Development, 6: (1992).

Sterman, John D. and others. "Unanticipated Side Effects of Successful Quality Programs: Exploring a Paradox of Organizational Improvement," Management Science, 43: 503-521 (April 1997).

Suzaki, Kiyoshi. The New Shop Floor Management: Empowering People for Continuous Improvement. New York: The Free Press, 1993.

Taylor, F. W. The principles of scientific management. In J. M. Shafritz and J. S. Ott (Eds.), Classics of Organization Theory (2nd ed., pp. 66-80). Chicago IL: The Dorsey Press (1987).

Thurston, Paul W. Class handout, ORSC 542 Management and Organizational Behavior. School of Logistics and Acquisition Management, Air Force Institute of Technology, Wright-Patterson AFB OH, June 1998.

Vita

Captain Jonathan D. Malone was born in Peoria, Illinois on 12 May 1964. He graduated from high school in 1982 and enlisted in the Air Force in 1983. His first assignment was at Offutt Air Force Base, Nebraska, as an aircraft maintenance specialist. Captain Malone entered the Bootstrap program to complete the requirements for a Bachelor of Science degree in Professional Aeronautics from Embry-Riddle Aeronautical University in December 1992. He was selected for Officer's Training School and received his commission on 11 August 1994. His first assignment as a maintenance officer was at Shaw Air Force Base, South Carolina. In May 1997, he entered the School of Logistics and Acquisition Management, Air Force Institute of Technology.

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13. ABSTRACT (*Maximum 200 Words*)

This study analyzed aircraft inspection data to determine if quality enhancements were realized after an Action Workout (AWO) was accomplished. Pretest and post-test assessment data from three separate units were analyzed to determine whether overall quality improvements were made. This study operationally defined quality in terms of Quality Verification Assessment ratings compiled before and after each AWO event. Comparisons were made to determine if overall quality improved, declined, or remained unchanged. Parametric t-tests and nonparametric chi-square analyses were used to determine the significance of any differences between the pretest and post-test data sets. The results provide plausible evidence that quality enhancements can be realized as a result of Action Workouts. Results at two of the three units analyzed indicate that overall quality of major aircraft inspection processes improved considerably, possibly as a result of the Action Workout intervention. Results at the third site, however, remained essentially unchanged. The evidence also suggests that many of the changes and improvement ideas implemented during the AWO are seemingly intact and being utilized by respective maintenance personnel. This may also indicate process owner "buy-in" and acceptance of change, two essential principles of quality improvement. This research establishes a firm foundation for future research efforts.

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